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Ethnobotanical survey about the management of diabetes with medicinal plants used by diabetic patients in Region of Fez-Meknes, Morocco

Hamza Mechchate, Imane Es-safi, Fatima Zahra Jawhari, Amina Bari, Andriy Grafov, Dalila Boustia

Research

Abstract

Background: Diabetes mellitus is a major public health problem in Morocco with more than 1.6 million cases of diabetes in 2017 with an expectation to rise to over 2.7 million cases in 2045. The aim of this work is to provide ethnobotanical information on some of the medicinal plants used by diabetic patients to treat their illness in the region of Fez-Meknes (Morocco).

Methods: A semi-structured and simple questionnaire was carried out. A total of 422 interviews were conducted with diabetic patients presented to diagnosis in the Hassan II Hospital center in Fez in Morocco. The data were analyzed through use value (UV) and relative frequency of citations (RFC).

Results: In total, 50 plant species belonging to 27 families were reported. *Lamiaceae* (14%), *Apiaceae* (12%) and *Fabaceae* (12%) were reported as the most represented families. Among the collected species, 6 plants were reported for the first time as antidiabetic plants in Morocco. The most frequently cited plant species are *Trigonella foenum graecum* (8.41%), *Olea europaea* (7.71%) and *Prunus amygdalus* var. *amara* (7.71%). Almost 67% and 33% of diabetic patient use medicinal plants as a complement and alternatives to their medication respectively.

Conclusion: This study showed the importance of medicinal plants in the healthcare system for treating diabetes. Knowledge of the use of medicinal plants that are used to manage diabetes may contribute to

their preservation and to undertake further pharmacological studies.

Keywords: Ethnobotanical survey, Diabetes, Management of Diabetes, Medicinal plant, Fez-Meknes, Morocco

Correspondence

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Background

Diabetes is a serious, chronic disease (WHO 1999). Raised blood glucose, a common effect of uncontrolled diabetes, may, over time, lead to serious damage to the heart, blood vessels, eyes, kidneys and nerves. More than 400 million people live with diabetes (WHO 2016). According to the International Diabetes Federation (IDF) there were 425 million people in the world with diabetes and this

is projected to increase to 629 million by 2045 (IDF 2017). In Morocco, diabetes mellitus is one of the most common metabolic diseases, there were over 1.6 million cases of diabetes in 2017 and it will rise to about 2,7 in 2045 (IDF 2017).

Diabetes occurs in two main forms, type 1 and type 2. Type 1 accounts for about 10% of diabetes cases, usually caused by an autoimmune attack on β -cells. pancreatic, inducing a decrease in insulin secretion. Whereas type 2 is mainly due to insulin resistance (Marx 2002) and accounts about 90% of the cases. It is usually associated with obesity or age.

All forms of diabetes are associated with a number of complications such as retinopathy, nephropathy, neuropathy and cardiovascular disease (King et al. 1998). These complications are due in part to a chronic rise in blood sugar, leading to damage to blood vessels. Currently, diabetes treatment relies heavily on diet, sports, oral hypoglycemic and insulin (Mohler et al. 2009)

Morocco is known for its rich vegetation and plant biodiversity with more than 5200 species and subspecies of vascular plants including 900 endemic plants (Fennane and Ibn Tattou 2012) and over 743 taxa belonging to 101 families and 371 genera. Among these taxa, 40 are endemic to Morocco of medicinal plants (Jamaledine et al. 2017). The use of medicinal plant and folk medicine date since immemorial time local folk medicine takes a huge part in Moroccan culture and it's by far the most

important source of remedies for primary healthcare (Bellakhdar et al. 1991)

Many studies showed how Moroccan deal with this chronic disease by using medicinal plants (Eddouks et al. 2002; El Amrani et al. 2010; Bousta et al. 2014; Skalli et al. 2019). However the use of medicinal plants by diabetic patient for treatment of Diabetes in the region of Fez-Meknes has not been conducted. Therefore, the aim of this study was to explore and identify medicinal plant species used by diabetic patients in Region of Fez-Meknes.

Materials and methods

Study area

The study was conducted with 422 diabetic patients in the Hassan II Hospital center in Fez, Morocco (Figure 1). The main hospital who receives patients from all the region which cover a wide geographical area to respond to a population of over 4 million population. There by covering the entire new Fez-Meknes region, which covers an area of 40,075 Km² or 5.7% of the national territory. This region is located in the Plain of Saiss, halfway between the north and the south of the Kingdom of Morocco. The maximum average temperature is 37 ° C and the minimum is 6 ° C. The region of Fez-Meknes is administratively two prefectures: the Prefecture of Fez and the Prefecture of Meknes and the seven provinces of Boulemane, El Hajeb, Ifrane, Moulay Yaâcoub, Sefrou, Taounate and Taza (Monographie Generale, 2015)

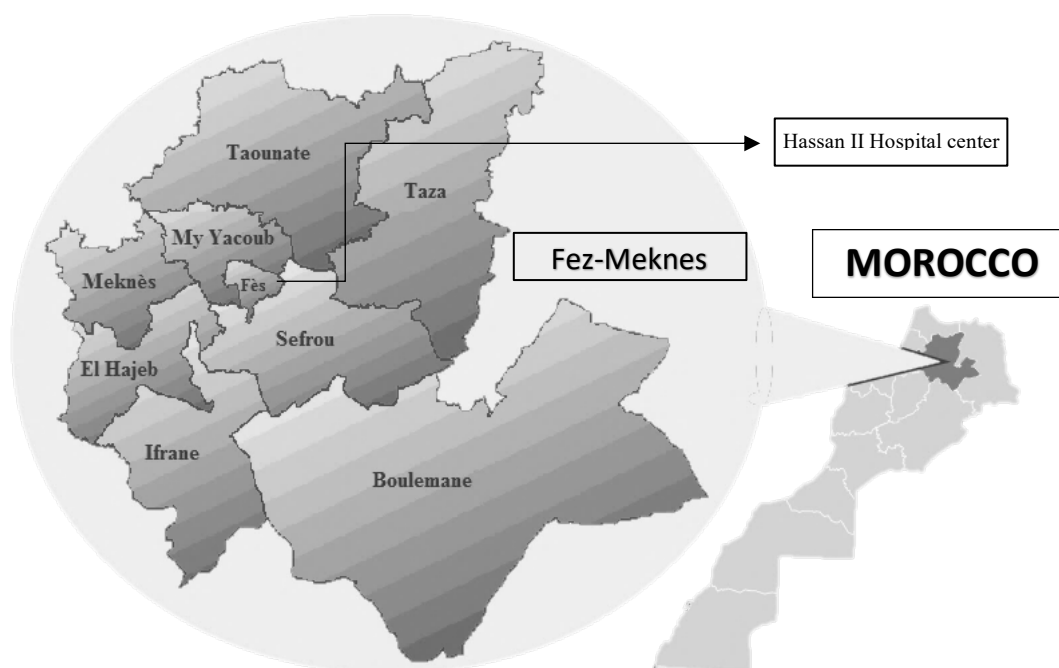


Fig. 1. Map of the study area

Data collection

An ethnobotanical survey was conducted from December 2018 to May 2019. The data were collected through a semi-structured and simple questionnaire (Annex A).

Plant identification

Local names, plant 'props' (freshly collected plant material or photographs) were used to identify the plants listed by the patients. Voucher specimens of each plant have been collected with the approval of patients and deposited at the herbarium of the Biotechnology laboratory and preservation of natural resources in the Faculty of Sciences, Dhar el Mahraz Fez. Identification of botanical names were undertaken in collaboration with Prof. Amina Bari (Botanist) and following the "Flore Pratique du Maroc" (Practical Flora of Morocco) (Fennane et al. 1999).

Data analysis

Fidelity level (FL)

Fidelity level is useful for identifying the key informants' most preferred species used for treating certain ailments. The medicinal plants that are widely used by the local people have higher FL values than those that are less popular. Fidelity level shows the percentage of informants claiming the use of a certain plant species for the same major purpose. This is designed to quantify the importance of the species for a given purpose.

FL value was estimated using the formula

$$FL (\%) = NP / N \times 100,$$

where Np is the number of informants that claimed a use of a plant species to treat a particular disease and N is the number of informants that used plants as a medicine to treat any given disease (Friedman et al. 1986).

Use value (UV)

The use-value is a quantitative method that demonstrates the relative importance of species known locally, calculated using the following formula (Phillips et al. 1994):

$$UV = \sum U / N$$

Where, "U" refers to the number of uses mentioned by the informants for a given species and "N" refers to the total number of informants interviewed. If a plant secures a high UV score that indicates there are many use reports for that plant, while a low score indicates fewer use reports cited by the informants.

Relative frequency of citations

The relative frequency of citation shows the local importance of each species and it's obtained by dividing the number of informants, who mention the use of the species, also known as the Frequency Citation (FC), by the number of informants participating in the survey (N) (Tardío and Pardo-de-Santayana 2008).

$$RFC = FC / N \quad (0 < RFC < 1)$$

Statistical analysis

Raw data entries were carried out using Microsoft Excel 2016 for windows, Frequencies were calculated with JASP

statistics version 0.9.2.0 for windows and figures were made with GraphPad Prism version 6.01 for windows.

Results and discussion

Socio-demographic profile of the diabetic patients

Our results (Table 1) indicate that women (83.65%) used medicinal plants more frequently than men (16.35%). This was also the result of other surveys conducted in different regions of Morocco (Ziyyat et al. 1997; Jouad et al. 2001; Eddouks et al. 2002; Tahraoui et al. 2007; Benkhniqie et al. 2014; Bousta et al. 2014; Skalli et al. 2019). This is related to the role of the women in the region in housekeeping and management of the house problems, having the knowledge of medicinal plants is by the time transmitted by mother and daughter and also by neighbor's, family and friend. This knowledge could be sometime helpful with minor and major health problems. Women are more attached than men to everything traditional.

The age repartition of the patient interviewed was: for those between 50-65 (53.1%) followed by those between 35-49 (34.4%) and for the ages between 25-34 and more than 65 it was 5.7% and 6.8% respectively our study matched earlier studies that have shown that the use of medicinal plants was more important in age categories between 30 and 60 years (Ziyyat et al. 1997; Jouad et al. 2001; Barkaoui et al. 2017) this category is represented by mostly married women who unroll their main activities in their house.

Most of our interviewed were illiterate with a frequency of 65.7% and about 25.8% who attended elementary school and 7.6% attended the Middle school and only 0.9 attended the university. Same as many other surveys (Ziyyat et al. 1997; Jouad et al. 2001; Benkhniqie et al. 2014; Barkaoui et al. 2017; Skalli et al. 2019) High frequency of illiteracy because of the participation of the girls in the house

activity to transmit all their knowledge about housekeeping and also the use of medicinal plants in daily life to be prepared to roll their own house in the future. Of the participants 88.1% were married, 6.2 widower, 3.2% were single and 2.5 % are

divorced. In order to reduce their expenses, married people tend to use cheaper and effective alternative to deal with their different illness, medicinal plant appear to be the first and perfect choice to start with.

Table 1. Sociodemographic profile of the diabetic patients

Variable	Subgroup	Number	Percentage (%)
Sex	Male	69	16,35
	Female	353	83,65
Age	25 - 34 years	24	5,70
	35 - 49 years	145	34,40
	50 - 65 years	224	53,10
	> 65 years	29	6,80
Educational level	Illiterate	277	65,7
	Elementary	109	25,8
	Middle school	32	7,6
	University	4	0,9
Familial situation	Married	372	88,1
	Single	13	3,2
	Divorced	11	2,5
	Widower	26	6,2

Sources of information

Their sources of information varied between Herboriste 6.2%, the internet 5.3%, books 1.7% explored by themselves 2.0% but their most important source was other experiences with 84.8% same as (Benkhnigue et al. 2014). This could be explained by the specialties of our society women tend to talk a with each other about their daily problems and this how many new medicinal plant knowledge is spread.

Reasons to use medicinal plants

Those who preferred the phytotherapical care justifying it by its effectiveness 69.2% and the 30.8% left were more convinced about its availability, low cost, and almost no side effect. In accordance with (Jouad et al. 2001) who find that the reasons for the use of medicinal plants are that these natural remedies are less cheap (53%) and more efficient than modern medicines.

Preference between modern and traditional healthcare

Almost the totality (421 of the 422) has indicated that they will consult medical personnel in case of sickness. This result reflects a good reasoning because the medical personnel is the only one who could provide true diagnosis.

Diversity of medicinal plants

In this ethnobotanical survey we recorded information on a total of 50 medicinal plant species, belonging to 27 families (Table 1). Information such as the local name of plant species, used parts, mode of preparation, ethnobotanical indices are provided for each species. Families with the most reported plant species were Lamiaceae (7 species, 14%), Apiaceae (6 species, 12%) and Fabaceae (6 species, 12%) (Figure 2). This result is in agreement with previous reports where these families were the most represented families in diabetes mellitus treatment in Morocco (Benkhnigue et al. 2014; Barkaoui et al. 2017; Skalli et al. 2019). Dominance of these families could be attributed to their abundance in the Moroccan flora (Fennane and Ibn Tattou, 2012). Among the 50 collected species, 6 plants were reported for the first time as antidiabetic plants in Morocco and 5 were reported elsewhere (Table 2).

Fidelity level, Use value and relative frequency of citation of the medicinal plants

Values of collected plants species ranged from 28.57 to 100% (FL), 1 to 3.50 (UV) and 0.23 to 8.41 (RFC). The UV of *Nigella sativa* L. and *Ficus carica* were reported to cure all diseases basing on their religion as a result their UV and FL was not calculated. (Table 3). Of the 50 inventoried species 20 plant species were identified with FL greater than 0.60: *Ammi visnaga*, *Coriandrum sativum*, *Foeniculum vulgare*, *Opuntia ficus-indica*, *Mill. Ceratonia siliqua*,

Lupinus albus, *Vicia faba*, *Lavandula stoechas*, *Marrubium Vulgare*, *Rosmarinus officinalis*, *Cinnamomum verum*, *Salvia officinalis*, *Linum usitatissimum*, *Myrtus communis*, *Olea europaea*, *Papaver rhoeas*, *Pinus pinaster* ssp. *hamiltonii* var *moghrebiana*, *Lolium multiflorum*, *Prunus amygdalus* var. *amara*, *Zygophyllum gaetulum*.

The plants that have less UV indicated that the plants are significantly used to treat diabetes in the area. Accordingly, a total of 12 plant species have a UV equal or less than 1.50. These plants were: *Ammi visnaga*, *Coriandrum sativum*, *Opuntia ficus-indica*, *Mill. Vicia faba*, *Lavandula stoechas*, *Linum usitatissimum*, *Myrtus communis*, *Olea europaea*, *Papaver rhoeas*, *Lolium multiflorum*, *Prunus Amygdalus* var. *amara*, *Zygophyllum gaetulum*.)

Based on RFC values, the most frequently used plants to treat diabetes. are *Trigonella foenum graecum* (8.41), *Olea europaea* (7.71), *Prunus amygdalus* var. *amara* (7.71), *Caralluma europaea* (6.31), *Marrubium vulgare* (4.44) and *Zingiber officinale* (3.97). Similar results were reported in other studies conducted in Morocco for *Trigonella foenum graecum* (Ziyyat et al. 1997; Jouad et al. 2001; Eddouks et al. 2002; Benkhniue et al. 2014; Boustia et al. 2014; Skalli et al. 2019), *Olea europea* (Jouad et al. 2001; Tahraoui et al. 2007; Benkhniue et al. 2014; Boustia et al. 2014; Skalli et al. 2019), *Marrubium vulgare* (Jouad et al. 2001; Eddouks et al. 2002; Barkaoui et al. 2017) and *Caralluma europea* (Benkhniue et al. 2014).

Previous laboratory analysis of *Trigonella foenum-graecum* has shown that the plant has a dose-related hypoglycemic effect in normal and diabetic rats (Khosla et al. 1995; Abdel-Barry et al. 1997; Raju et al. 2001; Xue et al. 2007) and in type II diabetic patients (Gupta et al. 1984). It has an effect also on glucose homeostasis (Abdel-Barry et al. 1997; Raju et al. 2001; Xue et al. 2007), insulin resistance (Gupta et al. 1984), insulin mimetic effect (Baquer et al. 2011), antioxidant and protective effect (Tripathi and Chandra 2010; Kumar et al. 2012). *Olea europea* has been also reported having a significant antidiabetic effect on diabetic rats (Eidi et al. 2009; Wainstein et al. 2012; El-Amin et al. 2013; Sangi et al. 2015) and on rabbits (Al-Azzawie and Alhamdani 2006). It attenuates early diabetic neuropathic pain (Kaeidi et al., 2011). It improves insulin sensitivity (de Bock et al. 2013). Therapeutic effect on lipidic and carbohydrate metabolism (Bennani Kabchi et al. 2000).

Plant parts used, mode of preparation and administration

Seeds were the most frequently used plant parts with a percentage of 33% followed by aerial part (31%) (Figure 3). Dried plants were mostly (59%) used to prepare the treatment and 41% used fresh plant parts. Decoction is the major preparation mode with a percentage of (39%), followed by powder (29%), raw (18%), juice (12%) and infusion (2%).

Plants used as complement or alternative medicine to conventional medicine

The use of medicinal plants were reported as complement (67%) and alternative (33%) to modern medicine (Table 3). Morocco is a country where the knowledge of traditional medicines is incorporated into its culture and is by far a very valuable heritage. Aside from sometimes its low efficacy which may explain the choice of conventional medicine by certain people over medicinal plants.

Conclusions

Several medicinal plants were being used in the study area to treat diabetes. Diabetic patients highly use medicinal plants as a complement and also as alternatives. Six plant species were reported for the first time in Morocco and 5 plants from elsewhere. The wide variety of medicinal plants that are used to treat diabetes and the frequency of citation support the important role of plants in the primary healthcare system of Moroccans. The wide variety of medicinal plants that are used to treat diabetes and the frequency of use among diabetic patients support the important role of plants in the primary healthcare system of Moroccans people. Development of the sector of medicinal plants is a major challenge to come for the scientific community from where the obligation to expand the research to validate or denied the use of certain plant against certain disease and aware people about their toxicity. Therefore, this documented information on the medicinal plants used in the region of Fez-Meknes may be used as baseline data for future pharmacological and phytochemical studies.

Declarations

List of Abbreviations: FL: Fidelity level; UV: Use value; RFC: Relative frequency of citations; F: Fresh; D: Dried; AP: Aerial part; S: Seed; R: Roots; Res: Resin; Epi: Epicarp; L: Leaves; Fr: Fruit; C: Complement; AM: Alternative medicine; ND: No data

Ethics approval and consent to participate:

Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.

Consent for publication: Not applicable

Conflict of interest: The authors declare that they have no conflict of interest.

Table 2. Medicinal plants used for the treatment of diabetes in the region of Fez-Meknes Morocco

Name of plants	Vernacular name	Citation	RFC	UV	FL	Citation in Morocco	Citation elsewhere
Apiaceae							
<i>Ammi visnaga</i> (L.) Lam. BPRN20	Bechnikha	9	2.10	1.44	69.23	(Bousta et al., 2014; Eddouks et al., 2002; Jouad et al., 2001a, 2002; Tahraoui et al., 2007)	(Demos et al., 2015)
<i>Apium graveolens</i> L. BPRN25	Krafess	8	1.87	1.88	53.33	No Data	(Gutierrez et al., 2014; ROGHANI et al., 2008; Roghani et al., 2007)
<i>Carum carvi</i> L. BPRN15	Karwiya	8	1.87	2.00	50.00	(Amrani et al., 2010; Barkaoui et al., 2017; Benkhniqne et al., 2014; Eddouks et al., 2002; El Jouad et al., 2001; Tahraoui et al., 2007)	(Eidi et al., 2010; Ene et al., 2008; Haidari et al., 2011)
<i>Coriandrum sativum</i> L. BPRN28	Kassbour	12	2.80	1.41	70.58	(Aissaoui et al., 2011; Tahraoui et al., 2007)	(M. Eidi et al., 2009; Gray and Flatt, 1999; Naquvi et al., 2004; Sreelatha et al., 2009; Sreelatha and Inbavalli, 2012; Waheed et al., 2006)
<i>Foeniculum vulgare</i> Mill. BPRN18	Hebet hlawa	8	1.87	1.62	61.15	(El-Hilaly et al., 2003; Tahraoui et al., 2007)	(Anitha et al., 2014; El-Soud et al., 2011; Mostafa et al., 2015; Özbek et al., 2003)
<i>Petroselinum crispum</i> Mill. BPRN30	Maadnouss	5	1.17	2.80	35.70	(Tahraoui et al., 2007)	(Bolkent et al., 2004; Ozsoy-Sacan et al., 2006; Sener et al., 2003; Soliman et al., 2015; Tunali et al., 1999)
Apocynaceae							
<i>Caralluma europaea</i> Guss. BPRN64	Daghmous	27	6.31	1.85	54.00	(Benkhniqne et al., 2014)	(Dra et al., 2018)
Asteraceae							
<i>Artemisia absinthium</i> L. BPRN46	Chiba	3	0.70	2.00	50.00	(Benkhniqne et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007)	(Daradka et al., 2014)
<i>Artemisia herba alba</i> asso L. BPRN16	Chih	15	3.50	2.33	42.85	(Benkhniqne et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007)	(Al-Waili, 1986; Awad et al., 2012; Boudjelal et al., 2015; Hamza et al., 2015; Taştekin et al., 2006)

<i>Chamaemelum nobile</i> L. BPRN35	Babounj	8	1.87	2.50	40.00	(Eddouks et al., 2002, 2005a; Lemhadri, 2007)	No data
Brassicaceae							
<i>Lepidium sativum</i> L. BPRN42	Heb rchad	2	0.47	3.00	33.33	(Bnouham et al., 2002; Eddouks et al., 2005b; Eddouks and Maghrani, 2008; Jouad et al., 2001b; Tahraoui et al., 2007)	(Attia et al., 2018; Rachid et al., 2012)
<i>Raphanus sativus</i> L. BPRN22	Fjel	3	0.70	2.00	50.00	(Barkaoui et al., 2017; El-Hilaly et al., 2003; Jouad et al., 2001b; Mrabti et al., 2019)	(Dehghani et al., 2011; Rachid et al., 2012; Shukla et al., 2011; Taniguchi et al., 2007, 2006; Vadivelan et al., 2012)
Burseraceae							
<i>Commiphora myrrha</i> (Nees) Engl. BPRN32	Lmorra	1	0.23	2.00	50.00	No data	(Ubillas et al., 1999)
Cactaceae							
<i>Opuntia ficus-indica</i> (L.) Mill. BPRN24	Hendia	7	1.63	1.00	100.00	(Berraaouan et al., 2015; Jouad et al., 2001b; Tahraoui et al., 2007)	(Butterweck et al., 2011; Enigbokan et al., 1996; Frati et al., 1990, 1990; Yang et al., 2008)
Chenopodiaceae							
<i>Chenopodium ambrosioides</i> L. BPRN27	M'khinza	3	0.70	2.60	37.50	(Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001b; Ziyat et al., 1997)	(Alonso-Castro et al., 2012; del Carmen Juárez-Vázquez et al., 2013; Song et al., 2011)
Convolvulaceae							
<i>Ipomoea batatas</i> (L.) BPRN39	Batata hlouwa	3	0.70	2.00	50.0	No data	(Kusano et al., 2001; Kusano and Abe, 2000; Li et al., 2009; Ludvik et al., 2008, 2004, 2003, 2002; Zhao et al., 2007)
Cucurbitaceae							
<i>Cucumis sativus</i> L. BPRN36	Khiyar	2	0.47	2.00	50.0	(Barkaoui et al., 2017; Hachi et al., 2016; Jouad et al., 2001b)	(Dixit and Kar, 2010; Heidari et al., 2016; Karthiyayini et al., 2015; Minaïyan et al., 2011; Sharmin et al., 2013)
<i>Cucumis melo</i> var. <i>flexuosus</i> L. BPRN38	Feqous	1	0.23	2.00	50.0	No data	No data

Fabaceae

<i>Ceratonia siliqua</i> L. BPRN61	Alkharoub	6	1.40	1.66	60.0	(Barkaoui et al., 2017; Skalli et al., 2019)	(Milek dos Santos et al., 2015; Rtibi et al., 2017b, 2017a; Yaniv et al., 1987)
<i>Cicer arietinum</i> L. BPRN21	Homos	2	0.47	3.0	33.33	(Kabbaj et al., 2012)	(Dilawari et al., 1981; Prathapan et al., 2011)
<i>Glycine max</i> (L.) Merr. BPRN40	Soja	5	1.17	1.8	55.55	(Barkaoui et al., 2017; Katiri et al., 2017; Mrabti et al., 2019; Tahraoui et al., 2007)	(Badole and Bodhankar, 2009; Benalla et al., 2010; Gina et al., 2016)
<i>Lupinus albus</i> L. BPRN41	Foul gnawa	9	2.10	1.00	100.00	(Eddouks et al., 2002; Haddad et al., 2001; Jouad et al., 2001b)	(Knecht et al., 2006; Mansour et al., 2002; Otoom et al., 2006; Wazaify et al., 2011)
<i>Trigonella foenum-graecum</i> L. BPRN45	Helba	36	8.41	2.02	49.31	(Barkaoui et al., 2017; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyyat et al., 1997)	(Abdel-Barry et al., 1997; Hannan et al., 2007, 2003; Raju et al., 2001; Vats et al., 2002)
<i>Vicia faba</i> L. BPRN51	Foul	3	0.70	1.00	100.00	No data	No data

Lamiaceae

<i>Calamintha officinalis</i> Moench. BPRN14	Manta	3	0.70	2.00	50.00	(Eddouks et al., 2017; Jouad et al., 2001b; Lemhadri et al., 2004)	(Singh et al., 2012)
<i>Lavandula stoechas</i> L. BPRN56	Khzama	6	1.40	1.50	66.66	(Barkaoui et al., 2017; Benkhnigue et al., 2014; Tahraoui et al., 2007)	(Sebai et al., 2013)
<i>Marrubium vulgare</i> L. BPRN55	Meriwta	19	4.44	1.57	63.33	(Barkaoui et al., 2017; Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007; Ziyyat et al., 1997)	(Boudjelal et al., 2015; Elberry et al., 2015; Herrera-Arellano et al., 2004; Vergara-Galicia et al., 2012; Yaniv et al., 1987)
<i>Mentha pulegium</i> L. BPRN49	Fliou	14	3.27	2.28	43.75	(Benkhnigue et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Ziyyat et al., 1997)	No data
<i>Origanum compactum</i> Benth. BPRN11	Zaater	6	1.40	3.50	28.57	(Eddouks et al., 2002; Jouad et al., 2001a; Ziyyat et al., 1997)	(Rachid et al., 2012)

<i>Rosmarinus officinalis</i> L. BPRN37	Azir	13	3.04	1.53	65.00	(Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyat et al., 1997)	(Al-Hader et al., 1994; Bakirel et al., 2008; Emam, 2012; Rachid et al., 2012; Ramadan et al., 2013)
<i>Thymus. vulgaris</i> L. BPRN19	Ziitra	13	3.04	2.23	44.82	(Benkhniguel et al., 2014; Eddouks et al., 2002; Jouad et al., 2001a; Tahraoui et al., 2007)	(Aljarah and Hameed, 2018; Koohi-Hosseinabadi et al., 2015; Telli et al., 2016)
Lauraceae							
<i>Cinnamomum verum</i> J. Presl BPRN63	Karfa	3	0.70	1.66	60.00	No data	(Zahmatkesh et al., 2012)
Liliaceae							
<i>Allium cepa</i> L. BPRN43	Bassla	4	0.93	2.50	40.00	(Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007)	(Campos et al., 2003; Kumari et al., 1995; Mathew and Augusti, 1975; Rachid et al., 2012)
<i>Allium sativum</i> L. BPRN52	Touma	3	0.70	2.66	37.50	(Barkaoui et al., 2017; Benkhniguel et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001a; Tahraoui et al., 2007; Ziyat et al., 1997)	(Ashraf et al., 2011; Eidi et al., 2006; Islam and Choi, 2008; Mostofa et al., 2007)
<i>Salvia officinalis</i> L. BPRN58	Salmiya	15	3.50	1.53	65.21	(Barkaoui et al., 2017; Bousta et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Errajaji et al., 2010; Orch et al., 2015; Tahraoui et al., 2007; Zayneb et al., 2015; Ziyat et al., 1997)	(Eidi and Eidi, 2009; Eidi et al., 2005; Kianbakht and Dabaghian, 2013; Lima et al., 2006)
Linaceae							
<i>Linum usitatissimum</i> L. BPRN57	Zeriat el Ketan	16	3.74	1.50	66.66	(Eddouks, 2017; Eddouks et al., 2002; Jouad et al., 2001a; Skalli et al., 2019)	(Ghule et al., 2012; Mani et al., 2011)
Lythraceae							
<i>Punica granatum</i> L. BPRN65	Reman	9	2.10	1.88	52.94	(Eddouks et al., 2002; Jouad et al., 2001a; Tahraoui et al., 2007)	(Das et al., 2001; Huang et al., 2005; Jafri et al., 2000; Li et al., 2005; Radhika et al., 2011)
Moraceae							
<i>Ficus carica</i> L. BPRN10	Tine	3	0.70	ND	ND	(Benkhniguel et al., 2014; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyat et al., 1997)	(Abo et al., 2008; Rachid et al., 2012)

Myrtaceae

<i>Myrtus communis</i> L. BPRN60	Rihane	3	0.70	1.00	100.00	(Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyat et al., 1997)	(Elfellah et al., 1984; Sepici et al., 2004)
<i>Eucalyptus globulus</i> Labill. BPRN23	Kaliptus	6	1.40	2.00	50.0	(Eddouks et al., 2002; Jouad et al., 2004, 2001b; Ziyat et al., 1997)	(Mahmoudzadeh-Sagheb et al., 2010; Rachid et al., 2012; Telli et al., 2016)

Oleaceae

<i>Olea europaea</i> L. BPRN12	Zitoune	33	7.71	1.36	73.33	(Benkhniq et al., 2014; Bousta et al., 2014; Eddouks et al., 2002; El Amrani et al., 2010; Jouad et al., 2001b; Orch et al., 2015; Tahraoui et al., 2007; Zayneb et al., 2015; Ziyat et al., 1997)	(Amin et al., 2013; A. Eidi et al., 2009; Eidi et al., 2004; Sato et al., 2007)
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Papaveraceae

<i>Papaver rhoeas</i> L. BPRN54	Belaaman	1	0.23	1.00	100.00	(Eddouks et al., 2002; Katiri et al., 2017)	(Allali et al., 2008)
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Pedaliaceae

<i>Sesamum indicum</i> L. BPRN66	Zenjlane	3	0.70	2.00	50.00	(Eddouks, 2017; Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007)	(Bhuvaneswari and Krishnakumari, n.d.; TAKEUCHI et al., 2001; Wikul et al., 2012)
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Pinaceae

<i>Quercus suber</i> L. BPRN13	Dbagh	1	0.23	3.00	33.33	No data	No data
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Poaceae

<i>Lolium multiflorum</i> Lam. BPRN48	Zwane	2	0.46	1.00	100.00	(Katiri et al., 2017)	No data
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Ranunculaceae

<i>Nigella sativa</i> L. BPRN53	Sanouj	9	2.10	ND	ND	(Eddouks et al., 2002; Jouad et al., 2001b; Tahraoui et al., 2007; Ziyat et al., 1997)	(Bamosa et al., n.d.; Fararh et al., 2002; Kanter et al., 2003; Meral et al., 2001)
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Rhamnaceae

<i>Zizyphus lotus</i> L. BPRN09	Sidra, nbeg	6	1.40	2.16	46.15	(Barkaoui et al., 2017; Jouad et al., 2001b; Katiri et al., 2017; Tahraoui et al., 2007; Ziyat et al., 1997)	(Benammar and Baghdad, 2014; Glombitza et al., 1994)
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Rosaceae

Prunus amygdalus Stokes var.
amara L.
BPRN17

Louze Imor

33

7.71

1.24

80.48

(Eddouks, 2017; Jouad et al.,
2001b; Merzouki et al., 2003)

No data

Zingiberaceae

Zingiber officinale Rosc.
BPRN62

Skinjbir

17

3.97

1.82

54.83

No data

(Al-Amin et al., 2006; Islam and
Choi, 2008; Mahluji et al., 2013)**Zygophyllaceae**

Zygophyllum gaetulum Emb. &
Maire
BPRN15

Aagaya

1

0.23

1.00

100.00

(Eddouks et al., 2002; Jaouhari et
al., 2000, 1999; Jouad et al.,
2001a; Tahraoui et al., 2007)

No data

Table 3. formulation and information about medicinal plants used for the treatment of diabetes in the region of Fez-Meknes Morocco

Name of plants	Part used/ State	Formulation, preparation and dosage	Other ethnopharmacological uses Reported	Complement or alternative medicine
Apiaceae				
<i>Ammi visnaga</i> (L.) Lam.	Umbel/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D	Asthma and Gastrointestinal ache	AM
<i>Apium graveolens</i> L.	AP/F	Juice, variable quantity mix with water, 1-2 C/D	kidney stones and Kidney problems	AM
<i>Carum carvi</i> L.	S/D	powder, 1-2 TS/D	Bloating, digesting problems	C
<i>Coriandrum sativum</i> L.	S/D	Powder, 1-3 TS/D	cholesterol	AM
<i>Foeniculum vulgare</i> Mill.	S/D	powder, 1-2 TS/D	bloating and stress	C
<i>Petroselinum crispum</i> Mill.	AP/F	Juice, variable quantity mix with water, 1-2 C/D	Kidney problems	C
Apocynaceae				
<i>Caralluma europaea</i> Guss.	AP/F or D	Juice, variable quantity mix with water or Milk, 1-2 C/D	Flu, tiredness, Cardiovascular problems, cancer, regulate menstrual cycle,	AM
Asteraceae				
<i>Artemisia absinthium</i> L.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D	Good to warm up in winter, diuretic	C
<i>Artemisia vulgaris</i> L.	AP/F or D	Decoction, handful quantity in 1L of water, 1-2 C/D	Gastrointestinal ache, antibacterial and antiseptic proprieties	C
<i>Chamaemelum nobile</i> L.	AP/F or D	Decoction, handful quantity in 1L of water, 1-2 C/D	stomachache	C
Brassicaceae				
<i>Lepidium sativum</i> L.	S/D	powder, 1 TS/D	cholesterol and Cardiovascular problems	C
<i>Raphanus sativus</i> L.	R/F	Raw, 1 piece/D ; juice, variable quantity mix with water, 1-2C/D	Hepatitis A, Antibacterial proprieties	AM
Burseraceae				
<i>Commiphora myrrha</i> (Nees) Engl.	Res/D	decoction 1 TS in 500 ml of water 1-2 C/D	aesthetic	AM

Cactaceae				
<i>Opuntia ficus-indica</i> (L.) Mill.	Epi/F or D	Juice, variable quantity mix with water, 1-2 C/D	No other uses mentioned	AM
Chenopodiaceae				
<i>Chenopodium ambrosioides</i> L.	AP/F	Juice, variable quantity mix with water, lemon juice 1-2 C/D	Antipyretic, headache	C;AM
Convolvulaceae				
<i>Ipomoea batatas</i> L.	R/F	Raw, 1-2 pieces/D	Cholesterol, anticancer	C;AM
Cucurbitaceae				
<i>Cucumis sativus</i> L.	Fr/F	Raw, 1-2 pieces/D	Antipyretic	C
<i>Cucumis melo</i> var. <i>flexuosus</i> L.	Fr/F	Raw, 1-2 pieces/D	Antipyretic	C
Fabaceae				
<i>Ceratonia siliqua</i> L.	Fr/D	decoction of powder, handful quantity in 1L of water 1-2 C/D	No other uses mentioned	C;AM
<i>Cicer arietinum</i> L.	S/D	Raw fraiche seeds 10-20 pieces/D	Against Digestion problems and diarrhea	C
<i>Glycine max</i> (L.) Merr.	S/F	Raw dried seeds 10-15 pieces/day; powder 1-3 TS/D		C
<i>Lupinus albus</i> L.	S/D	powder 1-3 TS/D	Aesthetic	C
<i>Trigonella foenum-graecum</i> L.	S/D	Infusion, handful quantity in 1 L of water soaked overnight 1-2 C/D; Powder 1-3 TS/D	increase appetite, breast milk production, weight gain, against cholesterol, Detox.	AM
<i>Vicia faba</i> L.	S/F	Raw fraiche seeds 10-20 pieces/D		C
Lamiaceae				
<i>Calamintha officinalis</i> auct.	AP/F	Decoction, handful quantity in 1 L of water, 1-2 C/D	Against different aches, Antipyretic	C
<i>Lavandula dentata</i> L.	AP/D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D	Cardiovascular problems.	C;AM
<i>Marrubium Vulgare</i> L.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D	Gastrointestinal problems, Antimicrobial, antiseptic and anti-inflammatory proprieties.	C
<i>Mentha pulegium</i> L.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D	Flu, respiratory problems, Rheumatism	C
<i>Origanum compactum</i> Benth.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D	Gastrointestinal ache, Antimicrobial, antiseptic proprieties	C
<i>Rosmarinus officinalis</i> L.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D	Digestion problems, against men erection problems.	C
<i>Thymus. vulgaris</i> L.	AP/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D; hydrolates 1-2 C/D; powder, 1-2 TS/D	Cholesterol, digestion problems and to have appetite	C
Lauraceae				
<i>Cinnamomum verum</i> J. Presl	Bark/D	decoction of powder, 1-2 in 500 ml of water 1-2 C/D	menstrual pain	C
Liliaceae				
<i>Allium cepa</i> L.	Bulb/F	Raw 1-2 pieces/D	cholesterol, inflammation and edema formation	C
<i>Allium sativum</i> L.	S/F	Raw 3-9 pieces	Cardiovascular problems, colon problems	C
<i>Salvia officinalis</i> L.	L/ F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D	menstrual pain, Cardiovascular problems	C
Linaceae				
<i>Linum usitatissimum</i> L.	S/D	powder, 1-4 TS/D	Bloating, cholesterol, food transit	C;AM

Lythraceae				
<i>Punica granatum</i> L.	Epi/D	Decoction, handful quantity in 1 L of water, 1-2 C/D, include with bread preparation	Kidney problems, Detox	C;AM
Moraceae				
<i>Ficus carica</i> L.	L/D	Decoction, variable quantity in 1 L of water, 1-2 C/D	All diseases	C
Myrtaceae				
<i>Myrtus communis</i> L.	L/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D	No other uses mentioned	C
<i>Eucalyptus globulus</i> Labill.	L/F or D	Decoction, handful quantity in 1 L of water, 1-2 C/D	Flu, Respiratory problems	C
Oleaceae				
<i>Olea europaea</i> L.	L/F	Decoction, handful quantity in 1 L of water, 1-2 C/D	Cholesterol, Cardiovascular problems, dental care	AM
Papaveraceae				
<i>Papaver rhoeas</i> L.	S/D	powder, 1-2 TS/D	No other uses mentioned	
Pedaliaceae				
<i>Sesamum indicum</i> L.	S/D	powder, 1-3 TS/D, include with bread preparation	Bloating, Digestion problems	C
Pinaceae				
<i>Pinus pinaster</i> ssp. <i>hamiltonii</i> var <i>moghrebiana</i> H. del Villar	Eco/D	Decoction, 1 TS in 1 L of water, 1-2 C/D	gastric ulcer, hair care	AM
Poaceae				
<i>Lolium multiflorum</i> Lam.	S/D	powder, 1-2 TS/D	No other uses mentioned	C;AM
Ranunculaceae				
<i>Nigella sativa</i> L.	S/D	Powder 1-2 TS, include with bread preparation	All disease	C
Rhamnaceae				
<i>Zizyphus lotus</i> L.	S/D	Decoction, handful quantity in 1 L of water, 1-2 C/D	Kidney problems	C
Rosaceae				
<i>Prunus amygdalus</i> var. <i>amara</i> L.	S/D	Raw dried seeds 3-7 pieces/day	Aesthetic, Stomach ache	C;AM
Zingiberaceae				
<i>Zingiber officinale</i> Rosc.	Rhi/F or D	Juice of fresh rhizome, variable quantity in water, 1-2 C/D, Powder of dried rhizomes 1-3 TS/D	flu, tiredness and anticancer	C
Zygophyllaceae				
<i>Zygophyllum gaetulum</i> Emb. & Maire	AP/D	Decoction, handful quantity in 1 L of water, 1-2 C/D	No other uses mentioned	AM

F: Fresh; D: Dried; AP: Aerial part; S: Seeds; R: Roots; Res: Resin; Epi: Epicarp; L: Leaf; Fr: Fruit; C: Complement; AM: Alternative medicine

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Annex A : Ethnobotanical questionnaire

Université Sidi Mohamed Ben Abdellah- Fès Institut National des Plantes Médicinales et Aromatiques

Modèle-Questionnaire d'Enquête Ethno-pharmacologique Prof D. BOUSTA

Fiche n° :

Classement (par thème, ordre alphabétique, région ou autre) :

.....

Documents annexées (photos, diapositives, herbiers...) :

1-RENSEIGNEMENT SUR L'INFORMATEUR

- Sexe : Femme.....Homme

-Age : 18-24 ☐ 25-34 ☐ 35-49 ☐ 49-65 ☐ 65≥ ☐

- Origine ethnique : -

- Commune:..... -

- Niveau d'instruction : Néant ☐ Primaire ☐ Secondaire ☐ Universitaire ☐

- Situation familiale : Célibataire ☐ Marié ☐

- Métier : HerboristeGuérisseur

.....Autres.....

- Comment vous avez eu ces connaissances ? Lui-même ☐ Expérience des autres ☐
Herboriste ☐

Livres ☐ Occasionnellement ☐ Autres ☐

- Exerce t-il d'autre pratique médicale traditionnelle ? Si oui, les

quels ?

- Que préférez-vous ? les soins médicaux ☐ Les soins phytothérapeutiques ☐

-Pourquoi?.....

-Qui consultez-vous en cas de maladie ? : Personnel médical ☐ Guérisseur ☐

-Autres

.....

2- RENSEIGNEMENT SUR LE PRATICIEN

Nom :.....Prénom :.....Age :

Lieu de Naissance : Lieu d'établissement :

Appartenance ethnique ou origine régionale:.....

Qualification et compétence du praticien :

Niveau d'instruction :

Depuis quand exerce t'il le métier de guérisseur ?.....

Qui l'a formé.....

S'il s'agit d'un praticien lettré, quels livres de médecine arabe possède-t-il ? Est 'il polyvalent ou exerce une spécialité ?.....

Est -il spécialisé dans le traitement d'une maladie ?

.....

A-t-il formé quelqu'un ?.....

2 – RENSEIGNEMENT SUR LE PRODUIT**2-1 Simple :****2.1.1 - Caractéristiques de l'habitat de la plante**

Sol :

Relief :

Climat :

Action anthropique :

Aire de répartition :

2.2 – Systématique

-Famille:

-Genre:

-Espèce:

2.3 Dénominations locales :

.....

2-1 Plante : (Seule)

Parties utilisées : Tige ☐ Fleurs ☐ Fruits ☐ Graine ☐ Écorce ☐ Rhizome ☐ Bulbe ☐ Latex ☐

Feuilles ☐ Plante entière ☐ Autres combinaisons ☐ :

.....

État de la plante : Fraîche ☐ Desséché ☐

Forme d'emploi : Tisane ☐ Poudre ☐ Huiles essentielles ☐

Lieu de récolte : Lieu d'acquisition:.....

Produit : local ☐ sauvage ☐ local ☐ cultivé ☐ importé ☐

Autres :

Conditions et modalités de la récolte : (saison, période du jour, etc.)

.....

Autres utilisations médicinales :

.....

2-2 Mixte : (recette)

Parties utilisées : Tige ☐ Fleurs ☐ Fruits ☐ Graine ☐ Écorce ☐ Rhizome ☐ Bulbe ☐

Feuilles ☐

Plante entière ☐ Autres combinaisons ☐ :

.....

État de la plante : Fraîche ☐ Desséché ☐

Lieu de récolte des plantes

.....

Lieu d'acquisition

.....

Produit : local ☐ sauvage ☐ local ☐ cultivé ☐ importé ☐

Autres :

Conditions et modalités de la récolte : (saison, période du jour, etc.).....

Traitement reçu par le produit: (séchage, pulvérisation)

.....

Indications (si celles-ci varient en fonction des parties, faire une fiche pour chaque partie).....

.....

Autres utilisations médicinales :

.....
.....

Toxicité, effets secondaires : toxicité pour l'homme et/ou le bétail, risque et effets indésirables :

.....
.....

Dose :

.....
.....

Mode de préparation :

.....
.....
.....
.....
.....

Autres ☐ :

.....

Posologie :

Pour les nourrissons : 1fois/jour ☐ 2fois/jour ☐ 3fois/jour ☐ Autres ☐ :

Pour les enfants : 1fois/jour ☐ 2fois/jour ☐ 3fois/jour ☐ Autres ☐ :

Pour les Adultes : 1fois/jour ☐ 2fois/jour ☐ 3fois/jour ☐ Autres ☐ :

Pour les personnes âgées : 1fois/jour ☐ 2fois/jour ☐ 3fois/jour ☐ Autres ☐ :

Durée d'utilisation (durée de traitement) :

Un jour ☐ Une semaine ☐ Un mois ☐ Jusqu'à la guérison ☐

Mode d'administration :

.....
.....
.....
.....

Utilisation Comme :

☐ Complément au médicament

☐ Alternative

Associations :

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.....

Autres informations :

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